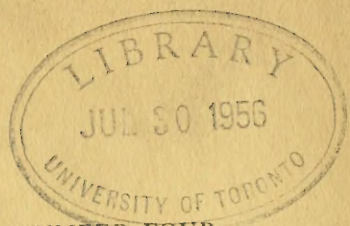
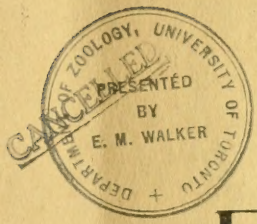


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# Journal of Entomology and Zoology

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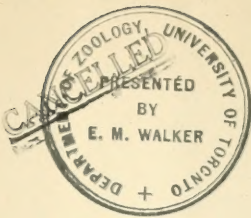
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THE JOURNAL OF ENTOMOLOGY AND ZOOLOGY

William A. Hilton, Editor

Claremont, California, U. S. A.





# New Species of Crane-Flies from the United States and Canada

(*Tipulidæ*, *Diptera*).

By Charles P. Alexander, State Natural History Survey, Urbana, Illinois.

Most of the new species described in the present paper were found among material sent to the writer for identification. I am greatly indebted to Mr. W. L. McAtee and to Mr. F. R. Cole for the privilege of studying and describing many of the species included in this paper. Two interesting forms were collected in southern Illinois during the season of 1919 by Mr. Malloch and the writer.

Family *Tipulidæ*.

Subfamily *Limnobiinæ*.

Genus *Dicranomyia* Stephens.

*Dicranomyia terræ-novæ* sp. n.

General coloration gray, the præscutum with three dark brown stripes; antennæ dark brown throughout, the flagellar segments short-oval; wings with a heavy dark brown pattern, including five large costal blotches; *Sc* short, basal deflection of *Cul* far before the fork of *M*.

*Male*.—Length about 5.5 mm.; wing, 7.6 mm.

*Female*.—Length about 7.5 mm.; wing, 7.7 mm.

Rostrum dark brown; palpi brownish black. Antennæ dark brown, the flagellar segments short-oval, clothed with an abundant pale pubescence. Head bright silvery on the front, duller on the posterior parts of the head; a conspicuous brown line on the vertex.

Pronotum dark brown. Mesothorax very deep, the mesonotum gibbous. Mesonotal præscutum light gray with three conspicuous dark brown stripes, the broad median stripe indistinctly split by a capillary line; scutum gray with the lobes dark brown; scutellum and postnotum gray, the latter with a delicate brown median line. Pleura light gray with an indistinct brownish longitudinal stripe extending backward from the fore coxæ; a similar line on the mesosternum. Halteres yellow, the knobs dark brown. Legs with the coxæ small, gray; trochanters dull yellow; femora brownish yellow, the tips indistinctly darker; tibiæ and tarsi brown. Wings whitish subhyaline with a heavy brown and grayish pattern, as follows: five dark brown blotches along the costal margin, the first near the wing-base, the third at the tip of *Sc* and the origin of *Rs*, the fourth at the tip of *R1*, the last at the tip of *R2+3*, suffusing the wing-apex; the first three of these markings reach the costa and pass into cell *R*; the fourth (stigmatal) is rectangular, connected with a blotch at the fork of *Rs*; narrow brown seams along the cord and the outer end of cell *1st M2*; large brownish gray clouds along the margin at the ends of the veins and at the anal angle of the wings. Venation: *Sc* short, ending just beyond the origin of *Rs*, *Sc2* indistinct, apparently somewhat removed from the tip of *Sc1*, this distance about equal to the basal deflec-

tion of  $M1+2$ ; basal deflection of  $Cu1$  far before the fork of  $M$ , this distance about equal to the basal deflection of  $M1+2$ .

Abdomen dark brown, the posterior margins of the segments broadly silvery.

*Habitat*.—Newfoundland.

Holotype, ♀, Spruce Brook, August 8-12, 1912 (G. H. Englehardt), (No. F3192).

Allotopotype, ♂.

Paratopotype, ♀.

Type in the collection of the American Museum of Natural History.

*Dicranomyia terra-novæ* differs conspicuously from all the described American species of the genus. Its vicarious Palearctic representative is *D. decora* (Staeger) of Northern Europe. Superficially it bears a marked resemblance to *Geranomyia rostrata* (Say), from which the structure of the mouth-parts and the slightly different venation will separate it.

#### Genus *Elliptera* Schiner.

##### *Elliptera illini*, sp. n.

General coloration brown, the pleura yellowish; cell  $1st\ M2$  open.

*Female*.—Length about 5 mm.; wing, 6 mm.

Rostrum pale brown, the palpi dark brown. Antennæ with the scapal segments pale yellowish, the flagellum black; flagellar segments oval with a sparse white pubescence and verticils that are a little shorter than the segments. Head dark brownish black.

Thorax dull yellow, the thoracic dorsum with the stripes brown and entirely confluent, shiny, only the lateral margins of the præscutum yellowish. Halteres dark brown, the base of the stem more yellowish. Legs with the coxæ and trochanters dull yellow; remainder of the legs brown, the base of the femora paler. Wings gray, the stigma indistinct; veins dark brown. Venation:  $Sc$  rather short, ending about opposite two-thirds the length of the long sector;  $Sc2$  proximad of the origin of the sector, the distance about equal to the basal deflection of  $Cu1$ ; basal deflection of  $R4+5$  almost square and in one wing of the type strongly spurred at the angle; cell  $1st\ M2$  open by the atrophy of the outer deflection of  $M3$ ,  $M1+2$  before  $m$  about one-half that beyond this cross-vein; basal deflection of  $Cu1$  just before the fork of  $M$ .

Abdominal tergites dark brown, the sternites yellowish.

*Habitat*.—Illinois.

Holotype, ♀, Makanda, Jackson County, June 4, 1919 (Alexander).

Type in the collection of the Illinois State Natural History Survey.

The unique type of *Elliptera illini* was found in the "Ozark" region of Illinois while Mr. Malloch and the writer were engaged in an entomological survey of this section. The genus *Elliptera* was hitherto represented by two species from Europe and two species from North America west of the Rockies. The occurrence of the genus east of the Mississippi River was quite unexpected and breaks the hitherto discontinuous distribution of this curious genus of crane-flies. The present species differs from its American relatives in the open cell  $1st\ M2$ , a character possessed by both of the European forms.



Genus *Orimarga* Osten Sacken.

*Orimarga wetmorei* sp. n.

General coloration black; thoracic pleura and lateral margin of the præscutum striped with silvery; legs pale yellowish brown, the tips of the femora a little paler; wings subhyaline, the veins pale brown; tip of *R1* atrophied or indistinct; deflection of *R4+5* very long.

*Sex*, female?—wing, about 4 mm.

The type is badly discolored. The general coloration is a dark brownish black; basal segments of the antennæ paler, the flagellar segments nearly globular.

The mesonotum has the extreme lateral margins of the præscutum narrowly silvery, the pleura with a broad silvery longitudinal stripe, this type of coloration being similar to that in *O. argenteopleura*. Legs light yellowish brown, the tips of the femora indistinctly paler; tarsi darker. Wings subhyaline, the veins pale brown, more yellowish along the costal margin. Venation: *Sc* moderately long, ending at about one-third the length of the long sector; *Rs* strongly arcuated at its origin; tip of *R1* atrophied or retreated back almost to the tip of *Sc1*; *r* very long and strongly arcuated; basal deflection of *R4+5* very long, strongly arcuated at its origin, more than half the length of *Rs*; cell *M3* deep; *r-m* far beyond *r*.

Abdomen dark brownish black, the apex broken.

*Habitat*.—Florida.

Holotype, Sex?, Paradise Key, February 22, 1919 (Alex Wetmore).

Type in the collection of the United States Biological Survey.

*O. wetmorei* is the sixth American species to be described, the second from the United States. The fly differs conspicuously from *O. arizonensis* Coq. (Arizona) in the coloration of the legs and body and in the venation. It is much more like *O. argenteopleura* Alex. (Guatemala) which has the thorax similarly colored; this latter species is considerably larger, with dark brown legs and a very distinct venation (tip of *R1* short, persistent; basal deflection of *R4+5* short).

The species is dedicated to the collector, Alex Wetmore.

Genus *Erioptera* Meigen.

*Erioptera (Erioptera) oregonensis*, sp. n.

Size large (wing of the male over 7 mm.); general coloration brown, including the halteres; wings with a strong brownish suffusion.

*Male*.—Length, 6 mm.; wing, 7.3 mm.

Rostrum and palpi dark brown. Antennæ dark brown, moderately elongate, clothed with a dense white pubescence, the verticils of the more terminal segments very long. Head dark brown, more grayish brown around the eyes.

Mesonotum dark brown with indistinct stripes on the præscutum, the lateral margins of which are indistinctly paler; humeral angles not noticeably brightened; tuberculate pits small, widely separated; scutum, scutellum and postnotum sparsely yellowish gray pruinose. Pleura dark brownish black, gray pruinose. Halteres long and slender, dark brown, only the base of the stem a little brightened. Legs with the coxæ dark, grayish pruinose; remainder of the legs dark brownish black, only the trochanters and the bases of the femora a little brighter. Wings with a strong grayish

brown suffusion; stigma dark brown; an indistinct brown cloud along *r-m* and the deflection of *R*<sub>4</sub>+5; veins dark brown. Venation as in the subgenus, the 2nd *Anal* vein strongly sinuate.

Abdomen dark brownish black with a paler brown pollen. Hypopygium a little brighter; pleurites short and stout, sparsely setigerous; two pleural appendages, the outer appendage larger, the outer end flattened and enlarged, along the margin with four parallel rows of fine comb-like points; inner appendage paddle-like, the blade suddenly enlarged, provided with a few setigerous punctures, at the extreme tip with an additional, powerful, curved bristle. Penis-guard straight, tapering gradually to the blunt tip; gonapophyses with the apices produced laterad into conspicuous triangular blades with the points directed laterad.

*Habitat*.—Oregon.

Holotype, ♂, Tillamook, March 26, 1919, (A. C. Burrill).

Genus *Ormosia* Rondani.

*Ormosia subcornuta*, sp. n.

Belongs to the *meigenii* group; closely allied to *O. cornuta* (Doane) but the veins stouter, the stigma distinct, and the details of the male hypopygium very different.

*Male*.—Length, about 3.5–3.8 mm.; wing, 4.3–4.7 mm.

*Female*.—Length, about 3.8–4 mm.; wing, 5 mm.

Rostrum and palpi dark brown. Antennæ moderately elongate, dark brownish black, the scapal segments slightly paler brown. Head gray, provided with conspicuous yellow setæ.

Thoracic dorsum brownish gray without distinct stripes, the lateral margins more yellowish; tuberculate pits shiny black, located close together, the distance between them less than the diameter of one. Pleura brown with a strong gray pruinosity; a large tuft of yellow setæ between the base of the wings and the base of the halteres and a second group immediately ventrad of the halteres. Halteres yellow. Legs with the coxæ dark, gray pruinose; trochanters dull brown; remainder of the legs dark brown, the bases of the femora a little brighter. Wings subhyaline; stigma large, dark brown; veins stout, dark brown. Venation: cell 1st *M*<sub>2</sub> open by the atrophy of the outer deflection of *M*<sub>3</sub>; 2nd *Anal* vein slightly sinuous on its distal half, converging toward the 1st *Anal* vein.

Abdomen dark brown. Male hypopygium with the pleurites stout, provided with numerous conspicuous setigerous tubercles that bear long yellowish setæ which become more elongate and stouter toward the tips of the pleurites; outer pleural appendage subglobular, armed with from 4 to 8 powerful, acute spines, the terminal spine large, along the outer face with microscopic, appressed denticles, the basal spine on the inner side of the appendage largest, strongly incurved; inner pleural appendage long, slender, with a strong spine before the tip to produce a bifid appearance. The most lateral pair of gonapophyses are sinuous, with a group of two or three teeth or spines on the inner face some distance before the tip, the slender apex beyond these slightly curved; the proximal pair of gonapophyses are almost straight, very slender, the tip with numerous indistinct denticles, at the extreme base with a few conspicuous spines; an additional pair of gonapophyses whose apices are conspicuously flattened, with the point of the blade directed laterad and slightly cephalad. Ninth sternite



with a broad spatulate blade, as in the *meigenii* group of this genus, the apex deeply notched medially.

*Habitat*.—Oregon.

Holotype, ♂, Forest Grove, March 26, 1919, (F. R. Cole).

Allotopotype, ♀.

Paratopotypes, 2 ♂s; paratypes, 1 ♂, 1 ♀, Hillsboro, April 1, 1919, (F. R. Cole).

This little species is evidently the Western representative of the common *O. meigenii* (O. S.) of the Eastern States, its general appearance being very like that species. In the structure of the male hypopygium, however, it runs closes to *O. cornuta* (Doane), which may be told by the different color of the wings and the structure of the hypopygium.

#### Genus *Gonomyia* Meigen.

*Gonomyia (Gonomyia) coloradica*, sp. n.

Belong to the *blanda* group, closest to *mathesoni* Alex.; general coloration yellowish, the præscutum with three broad, confluent stripes of reddish brown; wings with the petiole of cell *M2* long; male hypopygium with the structural details very different from those in *G. mathesoni*.

*Male*.—Length, about 4.5 mm.; wing about 6 mm.

Rostrum, palpi and antennæ dark brown. Head dark.

Pronotal scutum and the collare dark brown; pronotal scutellum pale. Mesonotal præscutum with three broad, reddish-brown confluent stripes, the humeral regions cephalad of the lateral stripes pale; scutellum pale. Pleura pale, indistinctly striped with brown. Halteres pale, the knobs dark brown. Legs with the coxæ and trochanters pale; femora light brown; remainder of the legs broken. Wings subhyaline, unspotted; stigma lacking; veins brown. Venation: almost as in *G. mathesoni* with the following details different: *R2* very oblique and apparently contiguous with the tip of *R1*; *R2+3* not angulated before the middle of its length and without a faint spur of *r* at this point; petiole of cell *M2* much longer, one-half longer than the fused portion of *Cu1* and *M*.

Abdomen light brown. Male hypopygium generally similar to that of *G. mathesoni*, differing as follows: The bifid pleural appendage is very similar in the two species, in the present species with the needle-like tip of the longest arm abruptly pale. The long, sinuous appendage in *mathesoni* is here represented by two, the longer of which is pale throughout, flattened, the long tip acicular and almost straight; the shorter appendage is flattened, before the tip a little expanded, with a long, slender, curved black-tipped apex. Near the base of these pleural appendages is a flattened subtriangular lobe which is covered with an abundance of short setæ; in *G. mathesoni*, this appendage is very small, cylindrical, with but few setæ and with a distinct finger-like spinous lobe on one side. Penis-guard distinctly trifid at its apex, the lateral black spines directed almost caudad, setigerous at their bases; a shorter median pale lobe.

*Habitat*.—Colorado.

Holotype, ♂, Longview, June 24, 1916 (E. C. Jackson).

Type in the collection of the United States Biological Survey.

Genus *Phyllolabis* Osten Sacken.*Phyllolabis latifolia*, sp. n.

General coloration light gray; wings pale gray, the stigma pale grayish brown;  $R2+3$  shorter than  $R3$  alone; cell  $1st\ M2$  short; male hypopygium yellow with the foliaceous appendage of the eighth sternite very broad and but indistinctly bifid at its tip.

*Male*.—Length about 6.5 mm.; wing, 7.5 mm.

Rostrum dark brown, heavily gray pruinose above; mouth-parts reddish brown; palpi dark brown. Antennæ moderately elongate, dark brown throughout, the flagellar segments long-oval, provided with venticils that are but little shorter than the segments. Head light gray with an indistinct black median line.

Pronotum rather large, heavily light gray pruinose. Mesonotal præscutum brownish gray pruinose without distinct stripes; pseudosutural foveæ black, short-triangular; tuberculate pits not evident; remainder of the mesonotum gray pruinose, the scutellum more brownish. Pleura clear light gray. Halteres pale. Legs with the coxæ and trochanters pale brownish yellow; remainder of the legs dark brown, the bases of the femora paler. Wings pale gray; stigma rather indistinct, pale grayish brown; veins dark brown;  $Sc$  and the abortive vein behind  $Cu$  more yellowish. Venation similar to *P. claviger* but  $R2+3$  shorter, less than  $R3$  alone; veins  $R2$  and  $R3$  more divergent,  $R2$  at the wing-margin being distinctly closer to  $R1$  than to  $R3$ ; cell  $1st\ M2$  shorter, especially the outer deflection of  $M3$ .

Abdomen brown, sparsely gray pruinose. Hypopygium light yellow, including the pleurites and pleural appendages. Genitalia similar to *P. claviger*, differing as follows: outer angle of the pleurite much longer, projecting conspicuously beyond the pleural appendages; dorsal pleural appendage not slender and strongly bent at mid-length but very broad and flattened, roughly subtriangular with the base narrowest. Foliaceous appendage of the eighth sternite very broad and flattened, widest at the base, thence with the sides almost parallel slightly expanded at the distal end, the caudal margin of this leaf-like lobe slightly concave, feebly or indistinctly notched medially.

*Habitat*.—Oregon.<sup>7</sup>

Holotype, ♂, Forest Grove, March 28, 1919 (F. R. Cole).

Genus *Tricyphona* Zetterstedt.*Tricyphona sparsipuncta*, sp. n.

Close to *T. septentrionalis* Bergr.; median præscutal stripe split by a pale line; wings subhyaline, the costal region more yellowish;  $r-m$  connecting  $R4+5$  and  $M1+2$ .

*Female*.—Length, 7.5–8.8 mm.; wing 9.2–11 mm.

Rostrum very short, transverse, dark brown, sparsely gray pruinose, the anterior margin with a row of a few long yellowish bristles; mouth-parts and palpi dark brown. Antennæ dark brownish black, the basal four or five segments enlarged and very crowded as in this group of species. Head dark brown above, the front and a narrow margin around the eyes and across the anterior part of the vertex light gray.

Mesonotum very high and gibbous. Mesonotal præscutum light grayish yellow, with three dark brownish stripes, the median stripe split by an indistinct pale capil-



lary line that is more distinct in front; the sides of the median stripe are nearly parallel; lateral stripes narrow, their anterior ends subacute; scutum with the lobes marked with brown; scutellum light gray. Pleura dark brown, gray pruinose. Halteres pale yellowish brown, the knobs dark brown. Legs with the coxæ brown on the outer face; trochanters dull yellow; femora and tibiæ dull yellow, tipped with dark brown; tarsi dark brown, the base of the metatarsi paler. Wings subhyaline, the costal and subcostal cells more yellowish; stigma oval, dark brown, paler distally; sparse brown clouds along the cord, at the fork of  $R4+5$ , along the outer end of cell  $1st\ M2$  and, less distinctly, at the base of the sector; veins dark brown,  $Sc$  more yellowish. Venation: The distance between  $Sc2$  and the origin of the sector shorter than the straight portion of the sector alone;  $Rs$  angulated and spurred at its origin; upward deflection of  $R2$  slightly oblique, inserted in  $R1$  rather far before its tip, so that  $R1+R2$  is greater than the deflection of  $R2$  alone; petiole of cell  $R4$  short, about one-fourth longer than  $r-m$ ;  $r-m$  inserted between  $R4+5$  and  $M1+2$ ; petiole of cell  $M1$  longer than this cell.

Abdomen dark brown; valves of the ovipositor reddish brown, strongly compressed, slightly upcurved at the tip.

*Habitat*.—Oregon.

Holotype, ♀, Hillsboro, April 1, 1919 (F. R. Cole).

Paratype, ♀, Corvallis, May 14, 1917 (Moulton).

The type is much larger than the paratype but undoubtedly refers to the same species. The fly is closest to *T. septentrionalis* Bergr. (Alaska) in its spotted wings but may be distinguished by the colorational and venational details as described above.

#### Subfamily Tipulinæ.

Genus *Tipula* Linnæus.

#### *Tipula mallochi*, sp. n.

Belongs to the *submaculata* group; close to *T. submaculata* Lw.; male hypopygium with the horns of the tergite short, outer pleural appendage not bifid, gonapophyses short, eighth sternite with two powerful decussate bristles.

*Male*.—Length, 15 mm.; wing, 17–17.4 mm.

*Female*.—Length, 20 mm.; wing, 18.5–19 mm.

Frontal prolongation of the head brown, more yellowish above; palpi pale brown. Antennæ bicolorous, the flagellum with the basal enlargement of each segment black, the remainder light yellow, on the apical segments a little more infuscated. Head yellowish brown with a sparse grayish bloom; a capillary dark brown median line.

Mesonotal præscutum dull brownish yellow with four rather narrow reddish brown stripes, the remainder of the dorsum yellowish. Pleura pale yellow, whitish pollinose. Halteres pale, the knobs dark brown. Legs with the coxæ pale whitish yellow; trochanters yellow; remainder of the legs darker. Wings pale gray, the base of the wings and the costal region more yellowish; stigma brown; a brown cloud at the origin of the sector; tip of the wing indistinctly darkened; obliterative area before the cord in the base of cell  $R2$ .

Abdominal tergites dull brownish yellow, on the sixth to ninth tergites dark brown; the caudal margins narrowly, the lateral margins more broadly, silvery;

segments two to five with a narrow longitudinal brown sublateral streak; sternites brown, the caudal margins of the segments pale. Hypopygium generally similar to *T. submaculata*, differing as follows: Ninth tergite with the lateral horns very short and broad, the tips acute, not long and tapering as in *submaculata*; outer pleural appendage short and broadly flattened, the apex subtruncated, with a few coarse setigerous teeth, in *submaculata* this appendage is more slender, tapering to the acute point, at about midlength on the outer margin with a prominent spine to produce a bifid appearance; gonapophyses broad and flattened at the base, the slender tips short, not long and sinuous as in *submaculata*; eighth sternite with a pair of strong reddish fused bristles that are decussate, in addition to the smaller setæ. In the female, the sixth and seventh tergites are dark brown, the ovipositor acute, the tergal valves being especially long and slender.

*Habitat*.—Illinois.

Holotype, ♂, Alto Pass, Union County, June 5, 1919 (Alexander).

Allotopotype, ♀.

Paratopotypes, 4 ♂ ♀; paratypes, 20 ♂ ♀, Makanda, Jackson County, June 4, 5, 1919 (Alexander and Malloch); 5 ♂ ♀, Dubois, Washington County, June 3, 1919 (Malloch).

Type in the collection of the Illinois State Natural History Survey.

*Tipula mallochi* is common in the "Ozark" region of southern Illinois during early June, when it flies with other species of the genus as *T. submaculata* Lw., *T. tuscarora* Alex., *T. translucida* Doane, *T. morrisoni* Alex., *T. mingwe* Alex., *T. umbrosa* Lw., *T. flavoumbrosa* Alex., *T. fuliginosa* Say, and, in proximity of low wet cliffs, with *T. ignobilis* Lw.



# Notes on Pacific Coast Pycnogonids

W. A. HILTON

The specimens reported on at this time were obtained at Laguna Beach in the summer of 1920. Their collection was more or less incidental to other littoral explorations. There is also included a list of forms obtained at other times and at other places, chiefly during the same summer at Pacific Grove.  
*Pallene californiensis*, Hall.

Two of these were collected at Laguna Beach.

*Lecythorhynchus marginatus*, Cole.

Twelve specimens collected at Laguna Beach from among mussels, under rocks, among algae, etc. One specimen was dredged of San Diego in 1916. Thirty-four were collected on the land side of Catalina Island at the Isthmus in quite a different type of locality from that which is usual. At this place there were few red Algae but masses of a rather fine brown rock-weed. On these plants, hydroids and bryozoans were quite abundant. Many more might have been collected if there had been time.

Among Algae in front of the Hopkins Laboratory at Pacific Grove 18 specimens of this species were found. One was collected at the "Big Tide Pool."

*Ammothella tuberculata*, Cole.

Twenty specimens found in front of the Hopkins Laboratory at Pacific Grove. One found at low tide in the "Big Tide Pool." None found at Laguna this season.

*A. bi-unguiculata*, Dohrn, var. *californica*, Hall.

Twelve of these obtained at Laguna Beach under stones. Three specimens at the Isthmus, Catalina Island.

*A. spinosissima*, Hall.

Seven specimens collected at Laguna Beach. Two obtained at Pacific Grove in front of the laboratory.

*Tanystylum intermedium*, Cole.

Twenty-five specimens from Laguna Beach.

*Clotenia occidentalis*, Cole.

Ten specimens from Laguna Beach. Sixty-three specimens from in front of the Hopkins marine station, some were found on plume hydroids and among Algae.

*Halosoma viridintestinalis*, Cole.

We usually find a number of this species at Laguna Beach but none were found this season. At Pacific Grove 68 were collected from masses of fine bryozoans from floating timbers.

*Amoplodactylus erectus*, Cole.

Specimens of this species may be obtained at Balboa among tubularian hydroids, a hundred or more were collected from this locality this year and one from Anaheim Landing with palm hydroids.

*A. californicus*, Hall.

Three specimens from Laguna Beach, 6 specimens from the Isthmus, Catalina Island, 1 specimen in front of the laboratory, Pacific Grove.

*Pycnogonum stearnsi*, Ives.

Seven specimens from Laguna Beach, 1 specimen from Pacific Grove.

(Contribution from the Zoological Laboratory of Pomona College)



*Uca musica*. Rathb.

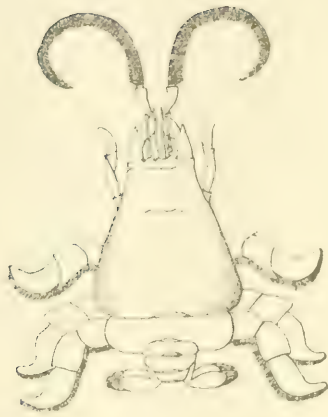
Drawn by J. Caldwell from specimens obtained by Caldwell and Miss W. Durant at Balboa mud flats during the summer of 1920. This is the first record of a fiddler crab in our region. The male is shown with the large claw. Sometimes the large claw was on the right, sometimes on the left. Specimens brought to the laboratory in moist sand made their burrows and lived all summer. In spite of the larger claws of the males they gave way to the females when in each other's way.





*Lepidoptera myops*, Stimp.

From Laguna Beach. Drawn by Joseph Caldwell.



*Eremita analoga*, Stimp.

Common sand crab of Laguna Beach. Drawn by Howard Lorbeer.



# The Nervous System and Sense Organs

BEGINNING WITH THIS ISSUE A SERIES OF ARTICLES  
WILL RUN FROM NUMBER TO NUMBER  
WITH CONTINUOUS PAGING

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By WILLIAM A. HILTON





## I. Plants

One of the common properties of living things is irritability. All living substance reacts, responds to stimuli, whether they come from the outside or from within. Transmission of stimuli is also a common property of living matter.

Plants are sensitive to many sorts of stimuli without much indication of organs of special sense. Only in certain cases are there tissues for the transmission of the effects of stimulation and central organs for coördination and control seem to be entirely lacking.

In unspecialized organisms, both plants and animals, the surfaces are sensitive to many sorts of stimuli without special organs for their perception. The whole surface or the whole body may in a general way be sensitive. If there are special parts associated with special stimuli, there are no histological features to indicate them. This diffuse perceptive capacity is more characteristic of plants than animals, yet some animals are of this type, and many plants have structures which are truly organs of sense, and in some cases special tissues for the transmission of the effects of stimulation.

In certain parts of most plants there are areas of surface where the perception of stimuli takes precedence over the protective or other functions; such surfaces may be called sensory. Certain cells or cell groups in plants which have perception as their chief or only function may be called sense-organs, even though they may not be responsible for sensation in the psychological sense. So far as we know, plants have developed sense organs only in relation to a few forms of external stimulation, such as those of contact, shock or jar, gravity or static and photic or light stimuli. So far as we can tell, the real act of perception, so-called, always takes place within the living substance, mainly or entirely in the solid portions, or in the ectoplast.

Tactile pits occur in the outer walls of some surface cells. The cell walls are thin at these points, which are just over the sensitive protoplasm within the cells. These pits are usually confined to the sides of tendrils which may come into contact with surfaces. Darwin first determined that tendrils can be stimulated only by contact with, or friction against, solid objects, not by the impact of water.

Tactile papillae, knobs and hairs occur on various parts of plants, such as staminal filaments. Parts of flowers which exhibit movements are often stimulated by means of hairs or knobs. Movements of parts of insectivorous plants are initiated by means of special sensory structures, such as hair, knobs, or spines.

Plants respond to light in general without special organs of sense, but it is probable that the epidermal cells of many leaves are

arranged in such a way as to favor the reception of light waves. This is, of course, not alone for sensation, yet sensation may be an important function. Some epidermal cells bulge considerably, especially in the velvet-like leaves of tropical forests. Such elevations make it possible for the cells to perceive photic stimuli, even when their surfaces are wet. Sometimes a whole cell bulges in a lens-like manner; sometimes the wall is thickened like a little lens, and by these methods the rays of light are brought to a focus upon the inner sensitive protoplasm. In many plants the whole upper epidermis is developed as a light-perceiving or photic epithelium. Also at times the margin or some definite locality has cells especially adapted to focus and receive rays of light. Such cells alone or in groups are conical with rounded tips, the apex of each has its wall thickened or almost biconvex. Such so-called ocelli have been proved to condense the light more effectually than the ordinary surface cell.

Stigmata or eye spots are found in certain plant spores and among the flagellates, such as *Volvox*, *Euglena*, etc. In *Euglena* the light-perceiving ability is confined to sensitive protoplasm near the pigment spot. The eye spot or pigment therefore acts as a light-screen.

Geotropic movements of plants are remarkable. The plants of high organization especially seem sensitive to the stimuli of gravity. Certain cells of roots, stems and leaves are provided with movable starch grains. It has been suggested that the movements of these starch grains bring about changes for growth and movements appropriate to the needs of the plants.

Transmissions of stimuli take place within cells from the points stimulated to more distant portions, but they cannot well be determined. When the sensory and the reaction organs are more widely separated the conduction is more obvious. In plants there are but few examples of transmission at a distance, for in many cases of marked movements in plants the sensory areas immediately adjoin the motor tissue. In other cases the transmission is at a greater distance. The velocity of transmission in plants is much lower than in animals. Heliotropic and geotropic stimuli are said to require five minutes to travel two millimeters, traumatic stimuli: 1-2 cm. per minute to 1-2 cm. a second. In case of the sensitive plant the transmission is 30-100 mm. per second.

Besides the transmission of impulses through the protoplasm of the cell there is the necessity for transmission from cell to cell. No special pathways have been clearly determined for the first in plants, but protoplasmic threads traverse the whole thickness of the cell walls. It is questionable whether there are special structures within plant cells for the conduction of stimuli. Strands between cells have been interpreted by some as the pathways of the effects of stimulation. There is no central organ of coördination known



and no distinction is needed between afferent and efferent pathways.

The only instance known of special tissues for the conduction of impulses is in the sensitive plant group and here it is quite definitely proved that living tissues are not necessary for the conduction of impulses and are in no sense comparable to the conductive tissues of complex animals.

## II. Protozoa

In *Amoeba*, there seems to be no portion of the surface more sensitive than others. The exoplasm is a general sensory organ.

Experiments by Hyman '17, with toxic substance show that a local region of increased susceptibility exists along the axes of each pseudopodium from its distal to its proximal end, the distal end being more susceptible. The youngest and most vigorous forms are most susceptible.

According to several investigators, the exoplasm of *Amoeba* is like a tough skin and this in part at least acts as a sensory area. The more fluid endoplasm may become quite rigid under stimulation.

The changes in *Amoeba* which are the causes of amoeboid movement and behavior originate within the *Amoeba* and external stimuli do not act directly to produce those physical alterations which result in movement, but they act through the protoplasm of the *Amoeba*. The reactions of *Amoeba* are similar to the reflexes of more complex forms involving reception of stimuli, and the conduction of internal changes leading to response, but sensation, conduction and movement are not differentiated.

If one side of an *Amoeba* touches some object it may move away from the source of stimulus. Jennings has found that when touched the animal does not usually move directly away from the side stimulated, but merely in some other direction. If the anterior edge is touched this part stops and contracts while the current turns to one side at this point, so that the animal moves at an angle with its former direction. If the advancing edge of an *Amoeba* is touched it withdraws and a new pseudopodium is sent out elsewhere. Sometimes *Amoebae* react positively to solid bodies, they may also under various sorts of stimuli thrust out many pseudopodia at once or draw all into a compact mass. *Amoeba* reacts not only to mechanical but also to chemical, temperature, light and electrical stimuli. The direction of movement in negative reactions is not determined entirely by the position of the stimulating agent. Other stimuli may have already altered the character of the protoplasm, for example the moving *Amoeba* is temporarily differentiated, having two ends different and the sides differing from the ends. These and perhaps other internal factors have a large part in the determination of movement.

It is impossible to explain how *Amoeba* alters its own metabolic process. If *Amoeba* is capable of self stimulation then this might suggest that living substance has a psychic quality which is possessed by all protoplasm. If this is not accepted for simpler organisms it would be hard to accept it for the cells of the cerebral cortex of man and all would be referred to present or past conditions of external or internal environment.

There is no clear evidence that *Amoeba* has memory. The



nearest approach to a suggestion of it comes from the observations of Jennings upon an *Amoeba* which attempted to devour one smaller. The ingested specimen escaped its captor, the larger reversed its movements and followed the smaller and again took it in. The behavior of the larger might seem to be partly determined by its earlier experience, but this might also be explained by a purely physical stimulus of a direct character.

Any elements of psychical qualities which *Amoeba* might pos-

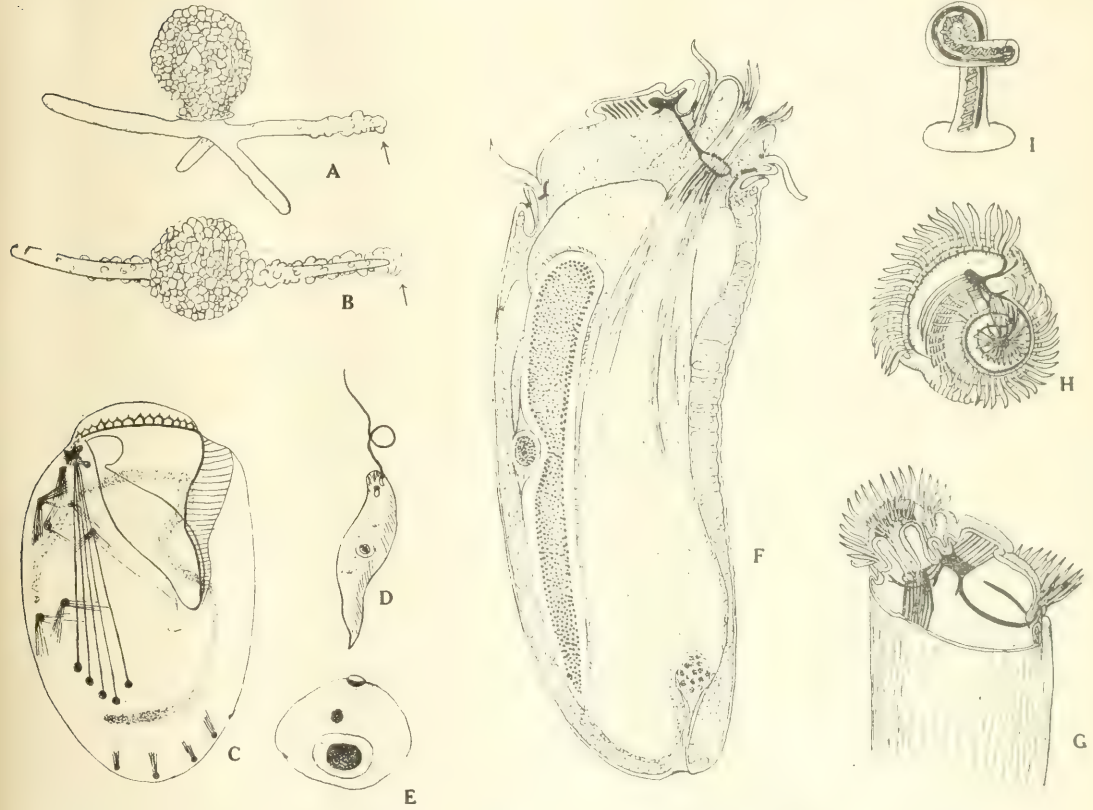


Fig. 1. NEUROMOTOR SYSTEMS AND SENSORY SYSTEMS OF PROTOZOA. A, B. *Difflugia* showing the effects of stimulating the ends of the pseudopodia. Verworn. C. Neuromotor system of *Euplotes*, Yocum. The motorium is dark, strands to the organelles and to the cirri shown by lines. D. *Euglena* showing eye spot near gullet and flagellum. Kent. E. *Gonium* showing eye spot above. Mast. F, G and H. Neuromotor system in *Diplodinium* after Sharp. The dark lines show the location of the chief parts of the system. F. Ideal section of the whole. G and H. Views from side and mouth end. I. Stem of *Vorticella* after Delage et Herouard, the contractile portion shown in dark, the conductive part in lighter.

sess are not capable of demonstration or proof. All that we can see is that if there are any elements of consciousness they must be of a very vague and elementary nature.

All forms of protoplasm have the property of irritability and there is usually also involved a certain degree of conductivity, but these are not always possible to measure or clearly determine. Verworn has made a study of conductivity in the elongated thread-like pseudopodia of some rhizopods. In studying the changes which take place in the long protoplasmic extension of *Diffugea* the results of stimulation may be directly observed. A weak stimulation at the end of the pseudopodium causes a slight wrinkling of the smooth surface, a stronger stimulus causes more swellings and more distant ones on the slender appendages. Fig. 1, A, B. The extent and rapidity of the wrinkling of the surface is in direct response to the strength of the stimulus applied. Other species of rhizopods gave similar results. The decrement of the intensity and rapidity becomes greater with the distance from the point of stimulation until the wave of excitation is obliterated. This is of course in sharp contrast to the conduction of a nerve fiber which normally conducts excitations without perceptible decrement of the intensity.

An organ for the control of amoeboid movement has been suggested, a centrosome or blepharoplast from which strands radiate to all the parts of the body which are concerned with locomotion, but no recent proof of this suggestion has come to my attention. According to Hyman the nucleus in *Amoeba* plays an important part in amoeboid movement, as is shown when the nucleus is removed.

Ciliate Protozoa such as *Paramoecium*, *Stentor*, *Vorticella*, etc., have much more complicated reactions than *Amoeba* because of their more complex structures, but the stimuli to which they respond are not much more complex or varied. The cilia are often highly specialized and localized; some coördination must be necessary. Cilia in general have been described in various ways as associated with small granules at their bases and strands from these granules have been described as penetrating into the cells, in some cases at least to be associated with a body of nuclear or cytoplasmic origin.

In 1880 Englemann found fibers in *Stylonychia* to which he assigned a nervous function. Neresheimer, 1903, found similar fibers in *Stentor*, and a number of others have described such structures without always being clear as to their function. Sharp, 1913, considers an elaborate system in *Diplodinium* which he calls a "neuro-motor apparatus." From a well-marked central body or "motorium" strands of substance were found going to the cilia and to various parts of the body in a complex manner. Fig. 1, F, G, H. Yocum, 1918, describes and figures a neuromotor system in *Euplotes*, developed from the ectoplasm. Fig. 1, C. It consists of



strands running from the motorium to sensitive areas, to the membranelles and to the long anal cirri. There are also strands connected with frontal, ventral, and marginal cirri, although these are not connected with the motorium. These cirri are irregular in their movements while the anal cirri are used chiefly in locomotion. These last as mentioned, have definite connections with the motorium. Yocum traces the homology of the motorium with the blepharoplast of many forms. This is the coordinating structure which serves to regulate anterior and posterior regions

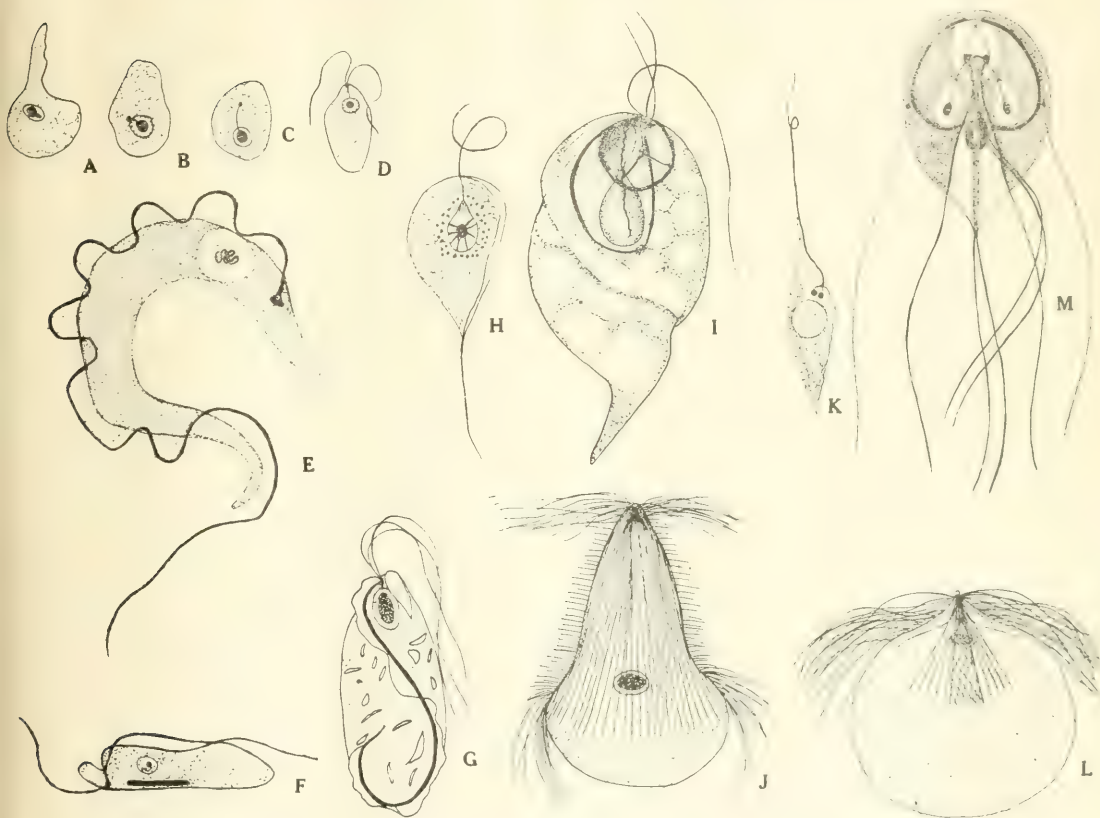


Fig. 2. NEUROMOTOR SYSTEMS OF FLAGELLATES. Nuclei and neuromotor apparatus mostly shown by dark lines or masses. A-D. Origin of blepharoplast from the nucleus in *Naegleria*. x 1040. E. Flagellate after Robertson. x 1200. F. *Trypanoplasma* after Martin. G. *Trichomitus* after Kofoid and Swezy. x 800. H. *Cercomonas* after Wenyon. I. *Chilomastix* after Kofoid and Swezy. x 3185. J. *Trichonympha* after K. and S. x 150. K. *Crithidia*, after McCulloch. x 1440. L. *Leidyopsis*, Kofoid and Swezy. x 200. M. *Giardia*, Kofoid and Christianson. x 2550.

of the body. The basal granules of cilia, cirri, and membranelles are considered as secondary rather than primary structures. In ciliates the connection between neuromotor apparatus and cilia is not clearly established, but there is some indication that there may be connection.

In many flagellate protozoans the flagellum has been described as springing from a center or blepharoplast. A very primitive type of neuromotor apparatus is described by Wilson, 1916. The flagellum arises from a blepharoplast which grows out from the central karyosome (Fig. 2, A-D). The blepharoplast is connected with the karyosome by a rhizoplast.

In other forms the blepharoplast may be composed of one or more granules which may or may not be connected with the nucleus. The basal granule of the flagellum may have a double function of being a basal granule of the flagellum and also a division center for the cell. In some forms the two functions are separated in two granules. In some a number of granules surround the blepharoplast or may be derived from it. These migrate backwards and come to form the parabasal body which may in some cases be attached by a number of fibrils to the blepharoplast. This parabasal body is interpreted as an accessory kinetic reservoir. A further elaboration of this structure is the chromatic rod of some species.

Various types of flagellates with their internal connections are shown in Fig. 3. One of the most complex conditions we find in *Giardia*, Kofoed and Christianson, 1915. This is a binucleate organism equivalent to two flagellates, each containing one nucleus and one blepharoplast at the end of a single axostyle, three flagella and a half or whole axostyle, depending upon the stage of the organism. Two blepharoplasts are connected by cross commissures and are anterior. The lateral flagella cross the middle line. The blepharoplasts are joined to the nuclei by rhizoplasts and also to the parabasal body lying along the axostyle. Each organism has its own neuromotor apparatus, but due to the crossing of the fibers between the blepharoplasts the two organisms are unified. (Fig. 2, M.)

According to Yocum and others the motorium of ciliates is homologous with the blepharoplast of flagellates. According to Dobell the blepharoplast of the protozoan is homologous with the end knob and the axial filament of the metazoan sperm, whose function is to provide for the locomotor activities of the cell. These structures are also homologous with the centrosome of resting cells.

It seems probable that other strands and coordinating centers may be found in protozoans in addition to those already described. This type of system for control or coordination is not in any sense homologous with that of Metazoa and in no sense does it lead to development of the nervous system of more complex forms. From what has already been said it is probable that methods of coordination are not at all alike in Protozoa and Metazoa; in fact it may well

be that the method in rhizopods may be of quite a different character than in the more specialized Infusoria and Mastigophora.

It is quite interesting that the neuromotor apparatus is derived from the ectoplasm. This corresponds to the probable conductive tissues in the protoplasm of plants and suggests a comparison between the origin of these parts, with the origin of the nervous system of Metazoa from the ectoderm.

Special sense organs in Protozoa are rare. In certain forms there are eye spots or masses of pigment as in *Euglena*, Fig. 1, D. and there are also eye spots or sensory areas in such forms as *Gonium*. Fig. 1, E.

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### III. The Sponges

The only activities of sponges which are in any way suggestive of sense organs or a nervous system are those connected with the water currents which enter and leave.

The currents are caused by collar cells distributed in the various chambers. These flagellate cells cause the continuous movements of the liquids under ordinary conditions. The flagella of these cells are connected with basal granules or blepharoplasts in each case and in some, connections are also made with the nucleus. Fig. 3, I, J.

Lendenfeld, 1885-7, has described sensory cells and ganglion cells in sponges, Fig. 3, E, F, G, but Minchin, 1900, and others believe there are no true nervous elements. No modern work has suggested the possibility of nerve cells or sense cells in Porifera.

Parker, in 1910, describes elongated spindle-shaped cells arranged like irregular sphincters around the gastral cavity, osculum, etc. Structurally they have the appearance of a primitive

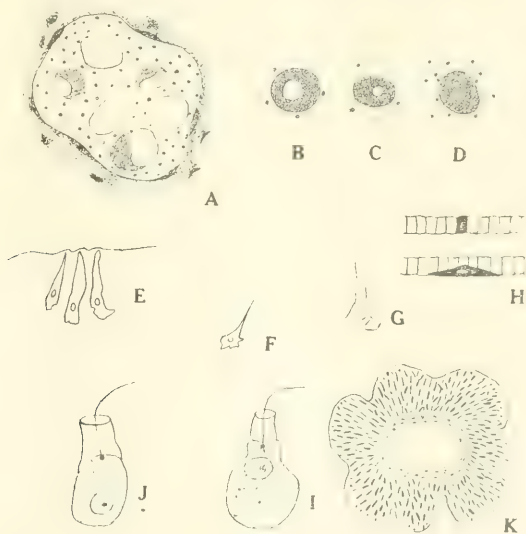


Fig. 3. STRUCTURES FROM SPONGES. A. Dermal membrane of a sponge seen from the exterior. Membrane pierced by six pores, three of which are partly closed by pore membranes. After Wilson, after Parker. B, C, D. Three stages in the closure of the membrane pore. After Wilson, after Parker. E, F, G. Sense cells and nerve cells, (?). After von Lendenfeld. H. Two stages in the development of a muscle cell as the first stage in the development of the nervous system. Diagram after Parker. I, J. Collar cells from sponges. After Robertson. x 1,000. K. Transverse section of the base of an oscular collar of a sponge showing the cavity surrounded by a sphincter of myocytes, spicules outside. Modified from Parker.

kind of smooth muscle fiber. As a result of their contraction the opening into the sponge is lessened or closed.

Wilson, 1910, describes membranes covering the subdermal cavity and containing pores. This so-called membrane is composed of an external portion and is believed to be syncytial. There are two somewhat independent devices for the closure of pores, the pore membrane and the pore canal sphincter. The closure of the pore canals is dependent upon the sphincter-like band of cells on the wall of the canal. These cells are in every way comparable to a primitive form of smooth muscle-fiber. They are in contact with the water passing into the canal and seem capable of direct stimulation. The pore membrane is less muscle like and is perhaps of a more primitive type.

Parker, 1910 and 1919, considers the sponges as an important group in illustrating the most primitive condition of the nervous system of metazoans. Muscle cells the independent effectors, as illustrated by the sphincters of sponges, were the first neuromuscular organs to appear. The special receptors in the way of sense-cells were next to appear in certain coelenterates while in other forms more complex, the adjuster or central organ was added.

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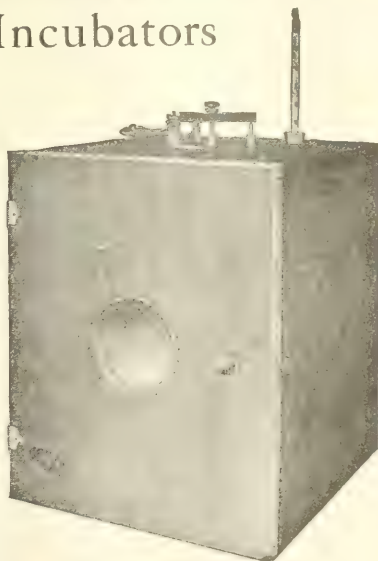
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